INTRODUCTION AND CLINICAL ASPECTS OF BIOCHEMICAL MONITORING OF THE FETUS

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General Introduction

Biochemical monitoring of the fetus during labor seen from the aspect of medical history as a whole is like an infant just born. But when considering it within the 25 year age of perinatal medicine it is like a steam engine of old generation. Its maiden voyage - the first fetal blood analysis - took place on 21st June 1960 (36).

Modern, safe supervision of the fetus during labor involves two methods:

1. Cardiotocography as a way of continuous electronic monitoring of the fetus to detect early signs of threatened hypoxia.
2. A biochemical method - at the present time, fetal blood analysis, which should only be employed as a complementary measure in cases with suspicious or pathological cardiotocogram.

An additional biochemical method enables us:

a. to clarify whether or not biochemical changes confirm imminent fetal hypoxia and/or acidosis which has been indicated by cardiotocography; and
b. to help in deciding whether further important clinical consequences like tocolysis for inhibition of uterine contractions or termination of labor by operation are necessary. In this way by using both cardiotocography and if

necessary additionally fetal blood analysis, it is possible to achieve a minimum of operative deliveries which is of advantage to the mothers, with an optimum of safety for the fetus.

From our many years of experience and in my own personal view, the consistent additional use of fetal blood analysis could have avoided some of the problems and criticisms which occurred in several countries during the past in connection with the sole use of cardiotocographic supervision during labor and the increased cesarean section rate.

Pathophysiology of fetal hypoxia during labor and consequences on the state of the newborn

Hypoxia leads primarily to an initial decrease in the pH values in the blood caused by the accumulation of CO_2 and thus to respiratory acidosis; this would be stage I in the illustratively demonstrated step-by-step development of hypoxia and acidosis (Fig. 1).
Secondly in stage II there is an additional overloading of organic acids, leading to combined acidosis. Due to anaerobic glycolysis this mainly concerns the lactic acid; the blood pH levels decrease still further.
In the third phase, in stage III the acidosis which has progressed in the meantime, and which is predominantly of metabolic character, begins to have a negative effect on the whole organism. The central nervous system becomes depressed and so - depending on the duration - incisive changes occur, having a depressing effect on the muscles, the reflexes, the respiration and the circulation. If the infant is born during this stage - that is stage III - reduced Apgar Score can often certainly be expected.

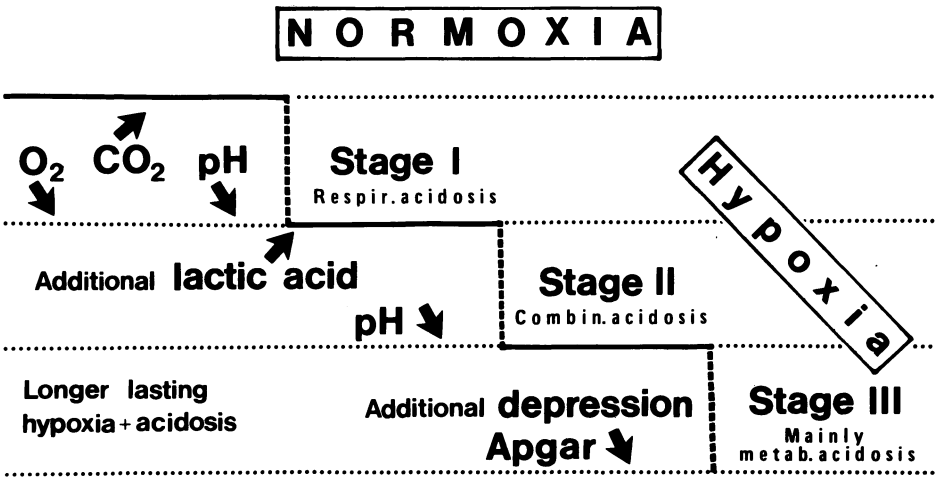

Figure 1

If other depressive influences play an additional role apart from the hypoxic causes described here, for example due to previous application of pain relieving drugs or anesthesia, then of course the Apgar Score can deteriorate earlier on.

The characteristics and clinical importance of these three pathophysiological stages are often being misunderstood. Situations occurring during labor are described for example a pathological CTG or even decreasing fetal pH-values, which are afterwards compared with the Apgar-Score. "False positive" findings during labor are said to have been present in infants where the Apgar-Score was "still" good. Bearing in mind what has already been said, it must be clear how naive this scientifically untenable conclusion is. Neither a pathological CTG caused by hypoxia nor decreasing pH-levels lead immediately - that is from the very beginning - to a reduced Apgar-Score. An appropriate long latency period must

be taken into consideration. If an infant is born before Stage III it will often still be vigorous. This is certainly not a "false positive" finding - from the clinical aspect - but rather a "correct positive" one.
To assess the state of the newborn only by using the Apgar-Score is antiquated and inadequate. This is why the state of the newborn should never be assessed by this method alone. Much better post partum hypoxia diagnostics in the newborn can be achieved by using a combination of the Apgar-Score and measurements of the pH in the umbilical cord blood, which we introduced into clinical routine practice in 1965 (27).

Suitability of fetal blood samples

As long ago as 1966 Desai et al. (11) reported a good correlation between pH blood gas values in samples taken from the newborn scalp and from a branch of the temporal artery so that they recommended scalp samples for monitoring newborn. Later Adamsons et al. (1) showed that there was an excellent correlation in experimental animals between blood samples from the scalp and from the carotid or jugular arteries. Between 1964 and 1970, Bowe et al. (6), Gare et al. (13), Kubli et al. (18), Teramo (37) and ourselves (5) all found that there was a good correlation during labor between values in human fetal blood samples and those in the umbilical vessels. O'Connor et al. (22) published - as far as FBA is concerned - a dissenting view. However later on several comments from various authors, namely Furi and Beard (12), Philip (23), Rooth et al.(25), including a contribution from ourselves (34) have disproved these statements. Our publication of 1976 (5) apparently unknown to O'Connor et al. pointed out that even in cases of moderate or marked caput succedaneum the correlation between the pH of scalp and of

umbilical arterial blood was surprisingly good. Concerning actual pH, r was 0.78 and for pH after equilibration, r was 0.79.

What do fetal scalp blood samples express?

We analyse microblood samples from the peripheral circulation. The composition does not differ too much from arterial blood, because the arterio-venous difference in the peripheral circulation is estimated as being relatively small on account of the low metabolism in the skin. There is no difference in the composition of the blood between arteries to the brain and those supplying the scalp, as they both receive blood from the same main branches of the aorta. Of course, it would be more informative to analyse venous blood from those organs of special interest, for instance from the brain. However, this is up to now scarcely possible in routine clinical work. However, for diagnostic purposes it is important to know that particularly in chronic hypoxia the fetus undergoes the so-called O_2 conserving adaptation of its circulation (31) and as a result of this pathophysiological mechanism the supply to the brain and heart is affected much later; other organs such as the skin, muscles and intestines are subjected to a reduced O_2 supply much earlier.
Recent results from simultaneous Doppler ultrasound investigations in the fetal common carotid artery and the fetal aorta achieved by ARABIN et al. in our institute (2) provide an interesting new confirmation of the O_2 conserving adaptation concept. In severely growth retarded fetuses ratio of blood flow volume of the common carotid artery to the fetal aorta was significantly increased.
It is also known from the pathophysiology of the cerebral circulation, that even in cases of significant changes of

blood pressure in the body circulation, a stable supply of blood to the brain is maintained, through the highly adjustable autoregulation of the brain circulation (19). Accordingly, we can assume that generally before the brain circulation is affected there will have been disturbances in the periphery, for instance in the muscles, leading to anaerobic glycolysis and to the overproduction of lactic acid. Thus, through fetal blood analysis and the falling pH values or increasing $tcPco_2$ values we get warning signs early enough, and can draw the necessary conclusions. Most of these considerations also concern the conditions using transcutaneous blood gas measurements.

It is rather doubtful whether - as Mann and coworkers (20) found - an isolated severe cerebral ischemia can occur with substantial head compression accompained by bradycardia, with subsequent permanent psycho-motor impairment of the infant. Follow-up examinations of children with increased intracranial pressure showed a higher incidence of abnormalities only after more than 20 hours of protracted labor (21). From these results it can be concluded that relatively short lasting head compression does not seem to be seriously dangerous.

We recently found in a prospective study performed together with Maria Brand concerning intracranial hemorrhage, that in cases with fetal bradycardia and/or variable decelerations in the cardiotocogram without an accompanying hypoxia (this means with normal pH-values), there was no higher incidence of cases with brain hemorrhage (7a, 7b). It is known that particularly hemodynamic factors are main causes of brain hemorrhage.

Suitable biochemical parameters for the clinical supervision of the fetus

For purely clinical purposes it is sufficient to perform only blood pH measurements. Direct blood gas measurements can be dispensed with, since simultaneously with the occurrence of hypoxemia, there is also a CO_2 increase which leads to a fall of pH-values and thus to a respiratory acidosis. Later an O_2 insufficiency leads to an increase of lactic acid content and to a metabolic acidosis of the infant through anaerobic glycolysis. Both kinds of increases in acidity can be ascertained by measurements of the falling pH-values. The growing possibility of continuous transcutaneous measurements in the fetus can provide interesting additional information; particularly the $tcPco_2$ measurements which will be reported later at this symposium by Dr. Schmidt who elaborated interesting results in our unit.

Non hypoxic acidity increase in the fetus

There is one possibility which should be excluded namely the so-called maternogenic increase of fetal acidity. This situation is caused by overflow of lactic acid from the mother to the fetus. To rule out such cases with maternogenic origin of acidity increase we recommend to measure maternal and fetal acidity and to compare either the actual pH-values which has been recommended by Rooth et al. (24) or the pH-values of metabolic acidity, which has been recommended by us (26). The latter means the pH after equilibration of the blood sample with 40 mmHg of Pco_2. We call this pH abbreviated pHqu40.

Such maternogenic increased acidity plays a clinical role in only about 10% in all cases with acidosis (Fig. 2) and only less than 1% in cases with more serious acidosis of less than 7.10 pH (14). If the difference between mother and fetus is less than 0.15 between the actual pH values or the difference of pHqu40 is less than 0.05, maternogenic acidity increase is confirmed. Such a situation is not as dangerous as acidosis caused by fetal hypoxia. Therefore it is not necessary to terminate the labor immediately by operation. An operative intervention would only be recommendable if pH decreases to slight acidotic values.

	No acidosis	Acidosis			
Type of acidity increase \ UApH act	7.29–7.20 (n = 590)	⩽ 7.19 (n = 268)	⩽ 7.09 (n = 77)	⩽ 6.99 (n = 20)	Σ (n = 858)
FAI_{S+R}	244 (52%)	226 (48%)	75 (16%)	20 (4%)	470 (100%)
MAI_{S+R}	346 (89%)	42 (11%) $p < 0.0001$	2 (0.5%) $p < 0.0001$	– $p < 0.04$	388 (100%)
FAI_S	359 (60%)	238 (40%)	76 (13%)	20 (3%)	597 (100%)
MAI_S	231 (89%)	30 (11%) $p < 0.0001$	1 (0.5%) $p < 0.0001$	– $p < 0.04$	261 (100%)
FAI_R	347 (59%)	244 (41%)	75 (13%)	20 (3%)	591 (100%)
MAI_R	243 (91%)	24 (9%) $p < 0.0001$	2 (1%) $p < 0.0001$	– $p < 0.04$	267 (100%)

Subdivision of the FAI and MAI newborns depending on their UApH-act values and the differently defined acidity increases
FAI = fetogenic acidity increase
MAI = maternogenic acidity increase
R = after ROOTH ($M/F\ \Delta\ pH_{akt} \leqslant 0.15$)
S = after SALING ($M/F\ \Delta\ pH_{qu40} \leqslant 0.05$)

Figure 2

Clinical benefits of additional biochemical monitoring

a) Advantages and disadvantages of cardiotocography

The controversies about intensive monitoring of the fetus during labor have arisen from the very beginning - that is since cardiotocography was first introduced into clinical routine practice in 1968. Two of the important questions to do with the suitability of this method were not properly differentiated from each other, namely:

1. with what reliability do suspicious or pathological heart rate patterns occur when fetal hypoxia and acidosis are really present (Fig. 3 upper part) and
2. how often is fetal hypoxia really present, when suspicious or pathological heart rate patterns occur in the cardiotocogram (lower part).

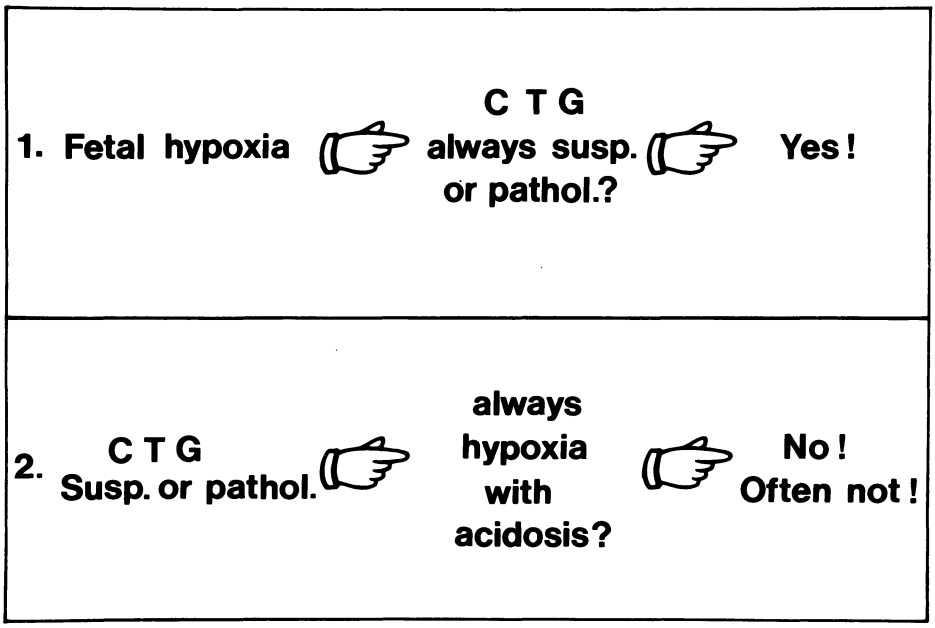

Figure 3

As regards the first point, cardiotocography is an excellent and reliable method, because one can be certain that almost all fetal hypoxias will be detected early enough by the occurrence of any abnormal heart rate pattern. This has however unfortunately led to the ill-fated erroneous assumption that there is an equally high reliability as far as the second question is concerned,- that is that suspicious or pathological heart rate patterns are always an expression of fetal hypoxia. This is definitely not the case for hypoxia and acidosis are often not imminent or present when suspicious or pathological heart rate patterns occur on the cardiotocogram. At the end of the sixties and beginning of the seventies (28, 29, 30, 32) we pointed out very clearly that cardiotocography was unreliable in providing correct evidence of threatened or existing hypoxia and acidosis. Even when all pathological heart rate patterns are present in such a severe form the cardiotocographic diagnosis can still be incorrect. We published such a record as far back as 1973 (33).

b) Our more recent results concerning cardiotocography and fetal pH-values

A more recent evaluation in our unit, drawn up together with Goeschen and Gruner, provides interesting results (15). 407 patients were continuously monitored by cardiotocography during labour and if suspicious or pathological heart rate patterns occurred were additionally monitored by fetal blood analysis. The cardiotocogram was assessed using the complicated, but still most reliable procedure, namely the Hammacher-Score (16). As far as cardiotocography can be exactly evaluated at all under strong scientific conditions, the Hammacher-Score is still the most objective procedure because all the three assessment criteria - the baseline fetal heart rate, the contraction related fetal heart rate, (the so called decelerations) and the variability of the baseline (the

so called fluctuations or oscillations) - the latter even with their number and with the amplitude - are included in this score. From our point of view a more objective assessment of a cardiotocogram does not exist.

Firstly it could be seen in our evaluations that (Fig. 4) also according to the Hammacher-Score in 80% of these cases the CTG could be regarded as abnormal; 3 or more points were present. In 78% of these suspicious or pathological cases (right part) the pH values of the fetus obtained by fetal blood analysis were optimal, that is 7.30 and better; in 12% they were slightly reduced but still within the normal range - that is between 7.29 and 7.25. Taken as a whole therefore, normal pH values were measured in 90% of these fetuses and prepathological or pathological values (pH below 7.25) in only 10%.

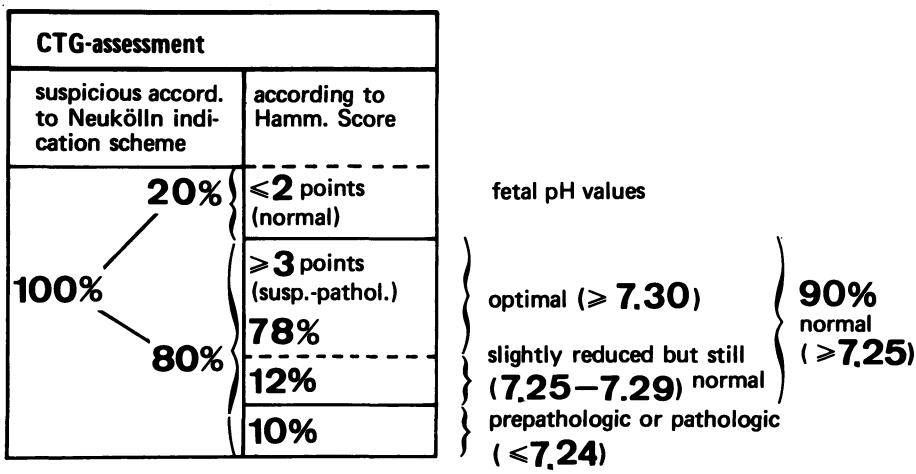

Figure 4

As was to be expected, the number of cases with reduced pH values increased as the CTG score deteriorated (Fig. 5). However it cannot be said that this would allow reliable clinical conclusions to be drawn. Even with prepathological and pathological CTG scores with 5 points and more the number of cases with preacidosis or acidosis only amounted to 26%.

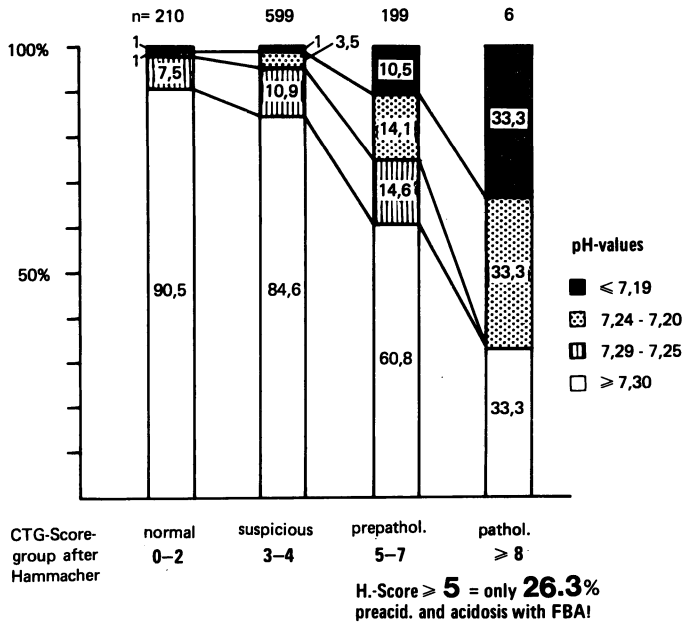

Figure 5

If, not having used fetal blood analysis, we had regarded an operative termination of the labour as indicated from 4 Hammacher Score points onwards - which is a logical clinical consideration - operative interventions would have been necessary in 73% of these risk cases concerned (Fig. 6) in order not to miss the 14% of fetuses who really were at high risk due to a fall in pH values. So here we have an over-diagnosis through cardiotocography of around 60%.

When using fetal blood analysis the following clinical results in all our cases were achieved: in 46% of the cases the delivery was spontaneous and in 54% operative. If the first stage and the second stage are subdivided, the following picture emerges:

in the first stage an operative delivery - mostly a cesarean section due to suspicious or pathological cardiotocogram - would have been indicated in 56% of the cases. After

performing fetal blood analysis, however, the cesearan section rate was only 10% - this means a saving of 46%.
Also in the second stage decisive advantages were found when combined monitoring was used. Here a CTG score of $\geqslant 4$ was recorded in 95% of the cases. Instead of having to operate on all these high risk cases, through the results achieved by fetal blood analysis, it was only really necessary to make an operative intervention in 54% of them. The remaining 41% infants could be delivered spontaneously.

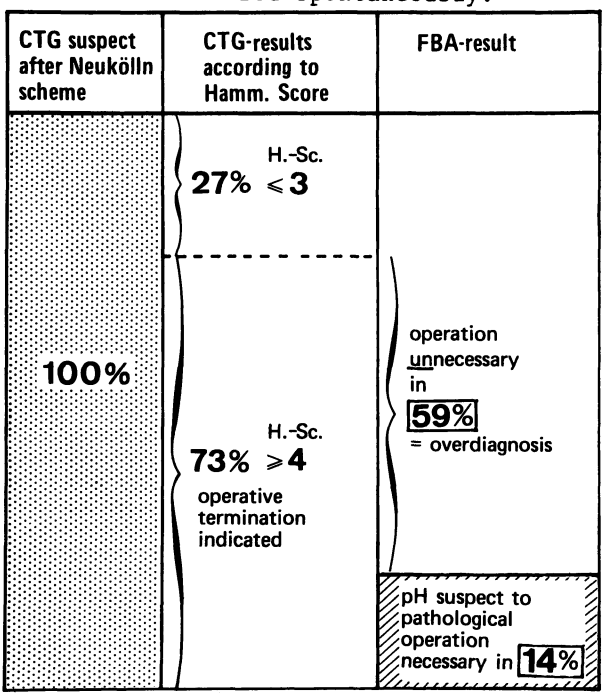

Figure 6

According to our experience fetal blood analysis is indicated in the early second stage, when the cervix is completely dilated but the presenting part is still in the pelvic inlet or in the mid-pelvic plane. When the presenting part is already in the pelvic floor or pelvic outlet (late second stage) and suspicious or pathological patterns occur in the cardiotocogram the labor is terminated immediately without

fetal blood analysis. In this case the operative intervention is fairly simple and therefore no advantage would be gained by awaiting the results of fetal blood analysis.
Operative interventions in the early second stage (vacuum extractions) - that is from the pelvic inlet or the mid-pelvic plane - can by no means be regarded as harmless for the fetus. Often they require difficult manipulation and should therefore only be performed when there is a strong clinical indication, and never without such a strong reason, for example when the CTG patterns are suspicious or pathological not due to hypoxia. In the already mentioned prospective study (7a,7b) we were able to show (Fig. 7) that intracranial hemorrhage (mostly slight) occurs twice as frequently in mature infants delivered operatively in the early second stage (10.5%) than in the late second stage (4.5%) and almost four times more frequently than in infants delivered spontaneously (2.6%).

Vaginal operative deliveries and ICH
according to SALING and BRAND
n = 218 ICH = 18 = 8.3%

	Mature inf. (≥ 37/0)			Premature inf. (< 37/0)		
	total n	ICH n	ICH %	total n	ICH n	ICH %
Pelvic inlet	30	2	6.7	1	0	(0)
Mid-pelvic plane	75	9	12.0	5	1	(20.0)
Early 2nd stage	105	11	10.5	6	1	(16.7)
Mid-pelvic plane – pelvic floor	37	2	5.4	7	1	(14.3)
Pelvic floor+ pelvic outlet	52	2	3.8	11	1	(9.1)
Late 2nd stage	89	4	4.5	18	2	(11.1)
Σ	194	15	7.7	24	3	(12.5)
Spontaneous delivery	801	21	2.6	87	19	21.8

Figure 7

At the 11th German Congress of Perinatal Medicine (35) in November 1983 we tried to give a less scientific but impressive and illustrative description of the advantages and disadvantages of cardiotocography in simple terms. For this purpose we took an example from nature. The cardiotocogram situation can be compared with the screaming of monkeys in the jungle: when danger is imminent they always scream. When there is a threat of hypoxia, the CTG is almost always suspicious or pathological. But monkeys have the typical attribute of screaming much too often; especially when there is no danger at all. The CTG often does this too, in the figurative sense. It is suspicious or pathological, but there are no real reasons to suspect dangerous fetal hypoxia - as measurements of the acid-base balance can clearly prove. This is unfortunately the reverse side of cardiotocography which many obstetricians either fail to recognize or push aside with naive credulity. If the newborn are vigorous after operative delivery - as regards their acidity and clinical state - then many colleagues excuse their management by saying that a hypoxia had just been avoided by well-timed intervention. Anyone who performs fetal blood analysis or even transcutaneous Pco_2 measurements, can give enough examples how often such excuses are self deception or a misguidance to the patient.

There has been so much speculation and so many hypotheses mixed with physiological and pathophysiological facts concerning the regular circle of heart rate behavioural patterns, that as far as daily clinical requirements are concerned reality is overlooked.

I assume internal specialists or anesthetists would laugh at us if we wanted to suggest in all seriousness, that it is possible to draw definite conclusions in adults as to whether the patient concerned was suffering from hypoxia or not merely by the interpretation of the heart rate patterns alone. This suggestion must appear to be even more curious, since biochemical methods of measuring parameters in the blood gases

and in acid-base balance have already been in existence for 25 years and provide a much more reliable diagnosis of hypoxia, namely a direct one. Unfounded arguments are used in the debate that fetal blood analysis is too complicated and too expensive. These ignore the high costs of staff, material and treatment caused by the numerous cesarean sections performed unnecessarily, and also the negative consequences of complications that often occur after such operations.

Comment on some publications concerning basic questions of biochemical monitoring

Modern intensive monitoring of the fetus during labor - and in particular biochemical monitoring - have sometimes been the subject of dubious criticism and arguments. The unshakeable belief in prospective studies can impair the judgement for clinical reality. For example HAVERCAMP et al. (17) have made comparisons between auscultatory, cardiotocographical and also cardiotocographical and biochemical monitoring in groups that were much too small. They also overlooked the fact that a purely auscultatory monitoring is not practised over a long period of time anywhere in the world under the same conditions as for such a prospective model study. The question has to be asked what is the practical clinical benefit of such studies at all. Furthermore in the few cases where intrauterine complications did in fact occur, the authors only then took the necessary action when acidoses had already occurred. It is not surprising that results were then achieved which did not show any differences between the compared methods.
These results which we think are misleading have been quoted a lot and have caused much confusion. When comparing the results of Havercamp and coworkers with our retrospectively evaluated material under the same group divisions, much worse

results were to be found in the Havercamp study (Fig. 8).

		total No.	patho-logical	%	significant difference
UApH≤7.20	Havercamp et al.	212	38	17.9	
	Our high risk cases FBA–group	1333	182	13.7	no
	Our total material 1978 + 1979 *	4720	437	9.3	yes, p:0.04
Apgar Score≤7 1min	Havercamp et al.	230	73	31.7	
	Our high risk cases FBA–group	1333	119	8.9	yes, $p < 0.001$
	Our total material 1978 + 1979 *	4649	282	6.1	yes, $p < 0.001$
Apgar Score≤7 5min	Havercamp et al.	230	12	5.2	
	Our high risk cases FBA–group	1330	22	2.9	no
	Our total material 1978 +1979 *	4350	75	2.7	yes, p: 0.02

* The total material from our department consistently includes a high percentage of cases with risk factors (in 1970 the rate amounted to 80.8%)

Figure 8

For example the number of "acidoses" in the umbilical artery blood at 18% was twice as frequent and significantly higher in the Havercamp group, compared to 9% in our group. Our total material contains a high percentage of risk cases. The difference in the 1 minute Apgar-Score is even more striking. The number of depressed infants amounted to 32% in the Havercamp group, and in our group it was only 6%. Even if we compare the Havercamp results with our highest risk group in which all cases had a pathological cardiotocogram and therefore fetal blood analyses were performed, the frequency of depressed infants (1 minute Apgar-Score 7 and less) was 9% in our group and 32% in the Havercamp group. Also our incidence of cases with "acidosis" was lower but not significantly. However, since - according to strict theoretical conceptions - apparently only prospective studies provide truthful results, such a comparison is open to attack.

We do agree with Havercamp on one point, that intensive monitoring during labor done in an unskilled fashion - particularly when cardiotocography is used exclusively - leads to an unnecessarily high rate of cesarean sections and other operative deliveries. Particularly this topic has been recently discussed in our publication together with van den BERG and S.SCHMIDT in the British Journal of Obstetrics and Gynaecology (4).

CLARKE and PAUL theorized in a publication in 1985 (10) and argued amongst other things, that in 25 perinatal centers in the United States fetal blood analysis had been performed on only about 3% of the parturients. They list six reasons for practical problems and thus explain why fetal blood analysis is not more widespread. According to our experience most of the reasons are of little or no importance. On the other hand, there were objections like unavailability of technical personell and equipment, technical difficulty in performing the procedure, time delay in obtaining results, misinterpretation of data, insufficient initial training. These problems would also seriously jeopardize any other medical procedure, if one were not able to solve such basic but typical difficulties of poor organisation, inexperience or prejudice. An objective observer will not be convinced by such a weak line of argument.

In our unit with about 3,000 deliveries per year and around 20% of cases with fetal blood analyses, none of the reasons mentioned above creates an essential practical problem which would make performing fetal blood analysis an unreasonably expensive or difficult procedure. In my opinion the authors of such publications - in the interest of an objective investigation should previously have visited the place where fetal blood analysis was developed and where - as in no other center - practical and clinical experience has been collected in the meantime on more than 17,000 cases, and should then check on the real reasons why there are so different opinions on biochemical monitoring.

Further, Clark and Paul (10) made some other statements, namely "... an acidotic scalp blood pH (< 7.20) was associated with an Apgar-Score of 7 and more, that is a false prediction of fetal compromise ... Another comment: "in recent large series it has been reported that 73% of infants with an umbilical arterial pH of less than 7.10, a level usually viewed as indicative for severe fetal acidosis, nevertheless had a one minute Apgar score of 7 and more. In 86% of these infants the five minute Apgar score was more than 7". They draw the following conclusions from this statement: "such data raise serious questions about the actual superiority of fetal blood pH measurement over fetal heart rate assessment in the prediction of fetal compromise." Concerning all these comments they overlook the fact that the consequences of intrauterine hypoxia have a step-by-step course as we have already clearly explained, and therefore the results which they find surprising are - pathophysiologically seen - apparently logical.

Many other examiners make the same mistake by comparing the results of biochemical monitoring during labor with Apgar Score and often also with umbilical pH values. They are then disappointed to find that there are so many so called "false positive" findings. Those authors believe as if it would be clinically inevitable for a newborn infant to be depressed or acidotic when suspicious or decreasing pH values have been present during labor. Also a deception lies in the fact that in addition to the pathophysiological facts mentioned above, the real clinical situation is not given enough consideration. Surely the aim of modern obstetrics is to deliver - if only possible - a clinically vigorous infant even after the first manifest signs of the beginning of intrauterine hypoxia have been detected, for example when the pH values have apparently fallen or transcutaneously measured Pco_2 levels have apparently increased, both in spite of the administration of tocolytic drugs.

If labor is in the first stage, then the obstetrician must also assess the latency period from the moment of the diagnosis to the probable time of the delivery by cesarean section. The decision-delivery time, which generally lasts from about 7 to 15 minutes in emergency cases, must be taken into consideration. In some cases the pH-values will improve up to the operative delivery of the infant, if the complications are of a transitory character. The number of such cases is however rather small. In the majority of the cases with confirmed progressive increase of acidity, the pH values drop to the prepathological range (7.24 - 7.20), sometimes even to the pathological range (< 7.20). If in such cases the fetus is delivered by operative intervention fast enough, then most of the newborn will have a normal Apgar Score (Fig. 9) as is to be expected after the step-by-step course of hypoxia described above. Therefore we should value the Apgar Score as a reference parameter in these studies with more caution. It is

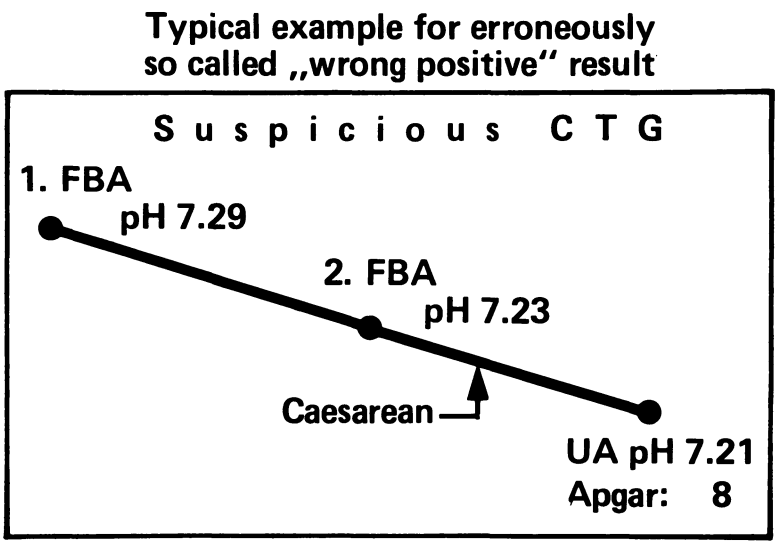

Figure 9

much more reliable to compare the findings of an acidity increase in the fetus with the pH levels in the umbilical artery blood.

After taking all these points into consideration, an equally high or even only slightly decreased pH level in the umbilical artery blood (Fig. 9) is an argument for a correct positive diagnosis and not - as is often maintained after incorrect observations - for a false positive one.

We should bear in mind that the prime concern is to find out how far a method of supervision fulfils the task which we expect from it. In this way too a great amount of confusion in the clinical observations on supposedly so frequent false positive findings could have been avoided.

We are just performing such a study together with Sabine Brand and P. van den Berg (8). Out of 110 fetuses (Fig. 10) which

"Correct" and "false" positive cases monitored by FBA

Operative delivery because of reduced FBA pH-values (< 7.25)		n = 110 = 100 %		
Umb.-art. pH	< 7.20	n = 62 = 56.4%	93.6%	"Correct" positive
Umb.-art. pH	7.20–7.24	n = 41 = 37.3%		
Umb.-art. pH	⩾ 7.25	n = 7 =	6.4%	"False" positive

After S. Brand, P. van den Berg, E. Saling

Figure 10

had an abnormal cardiotocogram and simultaneously reduced scalp pH-values (< 7.25), 94% had an equal or lower pH-value in umbilical artery samples. Only 6.4% had higher pH-values, this means that fetal blood analyses have been misleading and in so far are really "false positive".On the other hand only 4

newborns, that is 3.6%, have been severely depressed with an Apgar Score of 2 or less. As we have already pointed out in our comparison with the HAMMACHER-Score, cardiotocography for clinical purposes leads much too frequently to false diagnoses.
Clarke et al. made a good suggestion by introducing the fetal scalp stimulation in order to save a number of fetal blood analyses (9).
To a large extent we agree with the much discussed publications of Banta and Thacker (3) on the question of electronic fetal monitoring, that cardiotocography leads to a high rate of unnecessary cesarean sections, and that as a result there is an increase in maternal morbidity and mortality that could have been avoided.
When considering such aspects I am surprised to see that on the one hand American lawyers are very active in charging obstetricians when they have made a supposed or genuine mistake with regard to the impairment of the infant. On the other hand American lawyers have not yet realised what they could make by charging another kind of malpractice, - namely, that numerous avoidable impairment occurs particularly through maternal morbidity - because no high quality diagnoses is performed to avoid unnecessary cesarean sections. The mere thought of this prospect should inspire those colleagues who often operate unnecessarily, to perform better obstetrics.

We disagree with several conclusions of Banta and Thacker because - as previously described in detail - both these authors rely on the scientifically untenable assessment of the sensitivity of biochemical monitoring on account of the so called false positive results discussed several times in this presentation. Unfortunately therefore the basis of the many essential considerations in this otherwise well constructed and commendable study is lost to a high degree.

General review of intensive supervision during labor

The use of intensive supervision of the fetus during labor should also be regarded from a more superordinated point of view. We know that the birth process - even when uncomplicated - is a relatively short period of concentrated occurrences, which nowadays take their course within, lets say, less than 18 hours. In no other period of our life are we threatened by such concentrated risks in such a short space of time. It is also apparent that we recognize labor by the well known symptomes, like the start of contractions with or without the membranes having ruptured, and are thus able to recognize the beginning of the birth process. As a rule labor is not included among the unforeseeable events that happen unexpectedly, as for example is often the case with a heart attack. To know that moments of considerable danger are concentrated within a few certain hours of our life, and nevertheless to renounce on intensive supervision for such a period of time, is in my eyes reckless.

Final Remarks

In conclusion it should be said: combined cardiotocographical and biochemical supervision is inseparable and offers the highest possible safety concerning complications caused by hypoxia. Numerous observations in the literature show how often medicine is susceptible to subjective interpretations, pseudo argumentation and arbitrary statements.
I strongly recommend anyone who has still not been convinced by my arguments, to get acquainted with continuous transcutaneous blood gas measurements on the fetus,

particularly $tcPco_2$ registrations if he is not experienced with fetal blood analysis. I am in no doubt whatsoever, that the person concerned will then recognize at the latest the high clinical value of additional biochemical monitoring and also what was lacking in the past.

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